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A SUMMARY OF WATER PASTEURIZATION TECHNIQUES

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Much of this document is taken from: RECENT ADVANCES IN DEVICES FOR THE HEAT PASTEURIZATION OF DRINKING WATER IN THE DEVELOPING WORLD by Dale Andreatta, Derek T. Yegian, Lloyd Connelly, and Robert H. Metcalf, from the proceedings of the 29th Intersociety Energy Conversion Engineering Conference, American Institute of Aeronautics and Astronautics, Inc., 1994.

Introduction

Water quality and human health have been closely linked throughout history. However, it was not until the last quarter of the 19th century that pioneering work by Robert Koch and Louis Pasteur established the germ theory of infectious disease. With the understanding that fecal-borne bacteria, viruses, and protozoans were responsible for most water-borne diseases, it was possible to develop sanitation and water treatment practices which provided people with a safe water supply. In industrial countries safe water is now taken for granted.

In developing countries however, the burden of disease caused by contaminated water and a lack of sanitation continues to be staggering, particularly among young children. Diarrhea is caused by microbes entering the mouth, most often from contaminated water. According to the United Nations Children's Fund (UNICEF) diarrhea is the most common childhood disease in developing countries. Dehydration resulting from diarrhea is the leading cause of death in children under the age of five, annually killing an estimated five million children. Diarrhea is also the most common cause of child malnutrition, which can lead to death or permanently impaired mental and physical development.[1]

UNICEF estimates that 60% of rural families and 23% of urban families in developing countries are without safe water. In some areas all water supplies may be contaminated.[2] If a water source is suspected of being unsafe, the most common recommendation is to boil the water.[1] This recommendation is seldom followed for several understandable reasons, the most important being the time and the amount of scarce fuel it would require.

Contrary to what many people believe, it is not necessary to boil water to make it safe to drink. Also contrary to what many people believe, it is usually not necessary to distill water to make it safe to drink. Heating water to 65° C (149° F) for 6 minutes, or to a higher temperature for a shorter time, will kill all germs, viruses, and parasites.[3] This process is called pasteurization and its use for milk is well known though milk requires slightly different time temperature combinations. One obvious problem that arises with pasteurization is the question of how to tell when and if the water has reached the right temperature. Solutions to this problem will be covered in the next section. Pasteurization will not help if water is brackish or chemically contaminated.

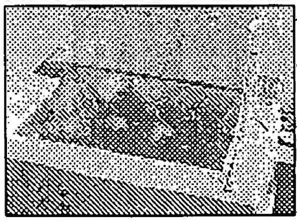
In this document we describe several pasteurization techniques applicable to developing countries. Pasteurization is not the only technique that can be used to make water safe to drink. Chlorination, ultra-violet disinfection, and the use of a properly constructed, properly maintained well are other ways of providing clean water that may be more appropriate, particularly if a large amount of water is needed. Conversely, if a relatively small amount of water is needed, pasteurization systems have the advantage of being able to be scaled down with a corresponding decrease in cost. As always, the selection of the right system should be based on local conditions.

This document describes techniques used to pasteurize water, but it is also necessary to educate people about the need

for clean water and how to keep their water clean. Among many people in the developing world clean water is not perceived as being important. Also, since many people do not understand how germs are transmitted, many cased have been reported where people unthinkingly recontaminate their clean water by putting it into a contaminated container.

Basic Methods of Solar Water Pasteurization-Solar Cookers

A simple method of pasteurizing water is to simply put blackened containers of water in a solar box cooker, an insulated box made of wood, cardboard, plastic, or woven straw.[3] A solar box cooker is sketched in Fig. 1. One popular



type of solar box cooker is made of aluminized cardboard and has a solar collection area of about 58 cm by 48 cm (23 inches by 19 inches). It has a reflective lid that increases the sunlight collected. With this device a yield of 4 to 12 liters (1 to 3 gallons) per day is achieved in the field. Each person requires about 4 liters (1 gallon) of water per day, about half of which is for drinking and the other half is for dish washing and brushing one's teeth. The cost for this device is on the order of $20, US, depending on how easily available the basic materials are.

Figure 1: A solar box cooker being used to pasteurize water.

Other types of solar cookers can be used. A recent development in solar cookers is the solar panel cooker, which consists of reflective panels that concentrate sunlight on the food. The food is in an oven roasting bag to reduce heat loss. Replacing the food with a darkened container of water makes a solar water pasteurizer. While the cost of these panel cookers is low, not more than 2 liters of water can be pasteurized at a time, though in the right climate several batches per day can be pasteurized.

Regardless of the type of solar cooker used, a way of knowing that the water reached the pasteurization temperature is needed. An inexpensive device that does this was developed, and is shown in the Fig. 2. It is a plastic tube with both ends heated, pinched, and sealed, and with a particular type of soybean fat in one end that melts at 154° F. The tube itself is buoyant, but is weighted with a washer so it sinks to the bottom (coolest) part of the water, with the fat in the high end of the tube. If the fat is found in the low end of the tube at any time after, the water reached the proper temperature, even though the water may have since cooled down. A nylon string makes it easy to take the tube out without recontaminating the water. The tube is reused by flipping it over and sliding the string through the other way. This device works in any size water container, costs about $3, and is available from Solar Cookers International, 1724 11th Street, Sacramento, California, 95814, (916) 444-6616. This device also works with fuel-heated water. Since heating the water to the pasteurization temperature rather than the boiling point reduces the energy required by at least 50%, the fuel savings offered by this simple device alone is considerable.

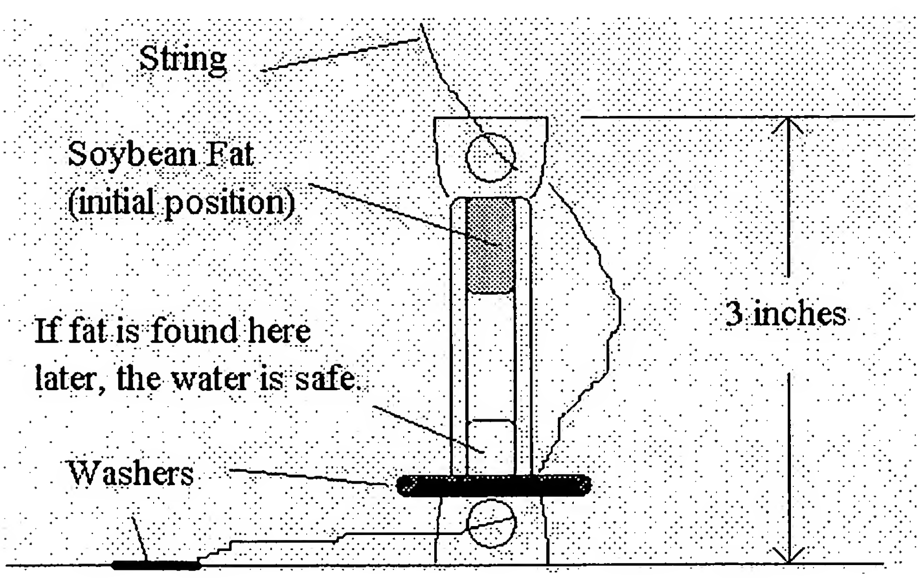
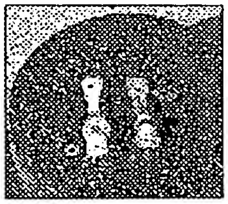


Figure 2: A Water Pasteurization Indicator. The indicator would sit at an angle in the bottom of a water

container.



This device works anytime when water is pasteurized in batches regardless of the source of the heat. If one were burning fuel to pasteurize pots of water the pasteurization indicator would still be usable, as long as one didn't get the nylon string too close to the fire. Since heating the water to the pasteurization temperature rather than the boiling point reduces the amount of energy required by at least 50%, the fuel savings offered by this simple device is considerable.

Flow-Through Pasteurization Devices

In order to produce more water PAX World Service produced a flow-through unit which consists of 15 meters (50 feet) of black-painted tubing coiled within a standard solar box cooker. One end of this tubing is connected to a thermostatic valve and the other to a storage tank for the untreated water supply. This storage tank also contains a sand/gravel/charcoal filter that does the preliminary filtering. The small amount of water (about 1.5 liters) within the tubing allows rapid heating of the water to the valve's opening temperature of 83.5° C (182° F). This is well above the required temperature, but the valve is derived from a mass-produced automotive radiator thermostat valve, so there is a limited selection of opening temperatures. The thermostatic valve opens allowing the pasteurized water to drain out of the tubing and into a second storage vessel for treated water. As the treated water drains from the solar box cooker, contaminated water from the storage tank automatically refills the tubing. Once this cool water reaches the valve the valve shuts and the pasteurization process begins anew.

This flow-through device addresses several of the problems inherent in the batch processes. First, potable water becomes available throughout the day as new increments of treated water are added to the clean storage vessel. Second, this type of unit can adapt to variable solar conditions which takes the guesswork out of filling the jugs in a batch process. If the insolation increases the time required to pasteurize and release the water in the tubing decreases, thus supplying increments of treated water at a faster rate. If insolation decreases the residence time in the solar box cooker will increase, but it will still be pasteurized which may not be the case in a batch unit where the user overestimated the amount of water which could be treated for that day. This is also a totally automatic process, freeing time for other chores and decreasing the likelihood of an accident occurring when transferring water in and out of a batch unit. Field trials by PAX World Service and the Pakistan Council of Appropriate Technology have regularly shown yields of 16 to 24 liters per day (4 to 6 gallons per day). The cost of this device is on the order of $50, US.

Although this is a respectable increase, much more dramatic improvements can still be achieved by recycling the heat in the outgoing pasteurized water. Once the water has been pasteurized and released from the solar box cooker the energy in this water can be used to preheat the incoming water. This process is shown in Fig 3. Since the temperature of the water entering the solar box cooker is higher, it takes less time to finish the pasteurization process, allowing more water to be treated. Also, the flow resistance of the heat exchanger smoothes the flowrate of the water.

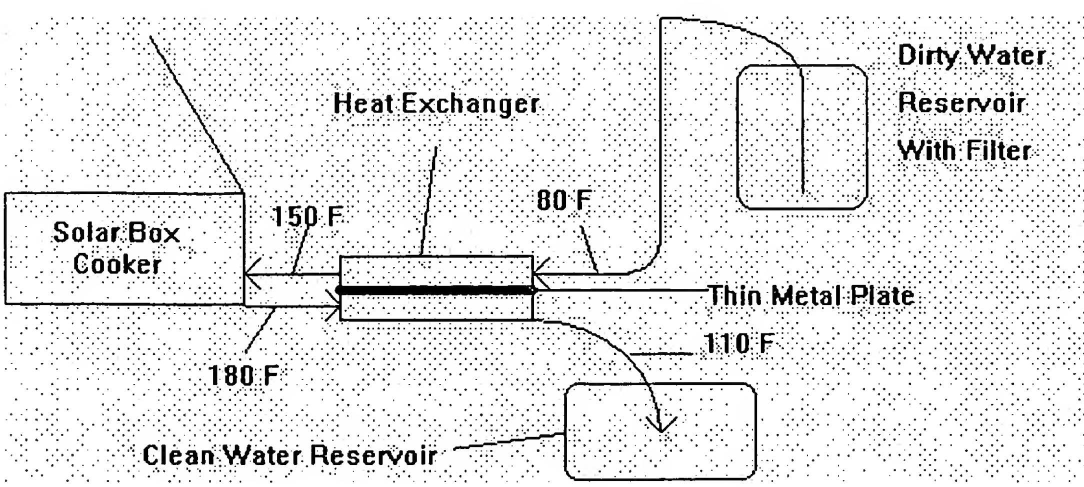


Figure 3: PAX -style water pasteurizer with heat exchanger. Typical temperatures are shown in degrees

Fahrenheit.

A simple device which accomplishes this preheating is a counter-current heat exchanger. The hot water flows on one side of a metal plate, while on the other side of the plate cooler fluid flows in the opposite direction. The energy from the hot water is transferred to the cold water, thus preheating the incoming contaminated water by lowering the temperature of the outgoing pasteurized water.

There are many ways of building a counter-current heat exchanger. Both a tubular version and a flat version have been tested using various configurations and materials, with experimental results favoring the less expensive flat version, though the tubular version is easier to construct from purchased parts. The flat plate unit allows between 75% and 80% of the energy to be reused in preheating the incoming water, and roughly four to five times more water will be pasteurized over a flow-through unit without a heat exchanger. This corresponds to about 80 to 96 liters (20 to 24 gallons) of treated water per day, which is a ten to twelve-fold improvement over the original solar box cooker batch method. An additional benefit is that the chance of burns is greatly reduced because the outflowing water is much cooler reducing the burn hazard. The cost of the heat exchanger itself is on the order of $15 US, making the cost of the complete PAX system about $65. Thus for an increase in cost of about 15% the heat exchanger provides about a 400% increase in water output.

Other Sources of Heat

A heat exchanger can produce benefits with any source of heat, including the exhaust heat from an engine, a fire (that may be used to cook food at the same time,) and heat from other types of solar collectors. We have done some engineering analysis and generated an equation to determine the water output of a particular system of this type. 4 This analysis can also be used to determine the relative benefits of a better heat exchanger, vs. a bigger solar collector vs. a better insulated collector.

If one went with a flame-heated system one would require a short piece of metal tubing, a thermostatic valve with housing, and a heat exchanger. The total cost of this type of system would be about $30. At present we have not done any experiments in this area.

The Solar Puddle-A Low Cost Large Area Device

While many factors determine the usefulness of a water pasteurizer, an important figure of merit is the water delivered per unit cost. A device which is made only of low cost materials is being called a "solar puddle" and it is essentially a puddle in a greenhouse. One form of the solar puddle is sketched in Fig. 4, though many variations are possible.

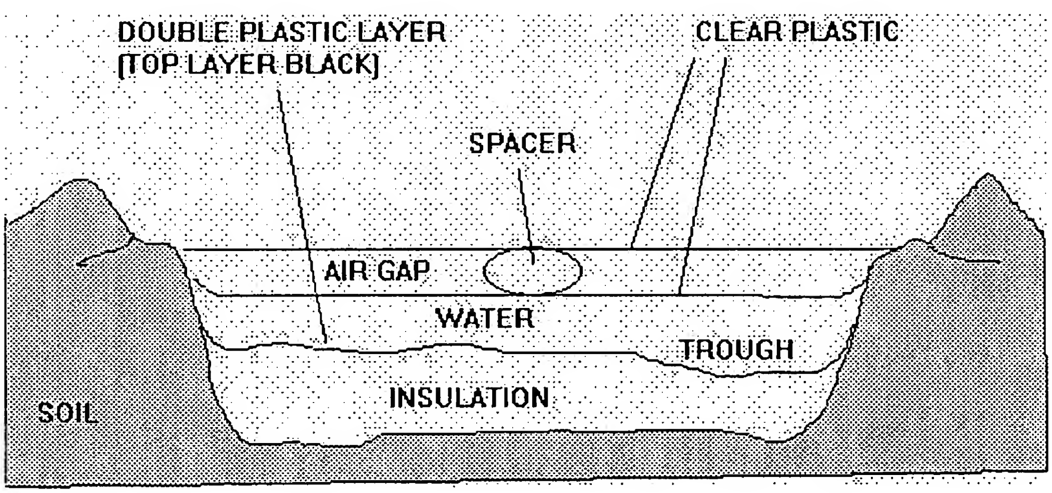


Figure 4: A basic solar puddle. Horizontal dimensions are shown compressed for clarity. A puddle can alse be built with wooden sides on top of a table or roof.

One begins by digging a shallow pit about 10 cm (4 inches deep). The test device was a "family-size" unit, about 1 meter by 1 meter (3 1/2 feet by 3 1/2 feet) but the puddle could be made larger or smaller. If the puddle is made larger there is more water to pasteurize, but there is also proportionately more sunshine collected. The pit is filled with at least 5 cm (2 inches) of solid insulation. We used wadded paper, but straw, grass, leaves, or twigs could be used. This layer of insulation should be made flat, except for a low spot in one corner of the puddle, which is marked "trough" in Fig 4. A layer of clear plastic and then a layer of black plastic goes over the insulation with the edges of the plastic extending up and out of the pit. Two layers are used in case one develops a small leak. We used inexpensive polyethylene from a hardware store, though special UV stabilized plastic would last longer. One would then put in some water and flatten out the insulation so that the water depth is even to within about 1 cm (1/2 inch) throughout the puddle, except in the trough which should be about 3 cm (1 inch) deeper than the rest. More water would be added so that the average depth is 2 to 7 cm (1 to 3 inches) depending on how much sunshine is expected. A pasteurization indicator should go in the trough since this is where the coolest water will collect. At this point the drain siphon should be installed. It should be at the lowest part of the trough so that the most water will be siphoned out before the siphon starts to draw air. The end of the siphon should be held solidly in place by a weight or by several rocks. A layer of clear plastic goes over the water, again with the edges extending beyond the edges of the pit. An insulating air gap is formed by putting one or more spacers on top of the third layer of plastic (large wads of paper will do) and putting down a fourth layer of plastic, which must also be clear. The thickness of the air gap should be 5 cm (2 inches) or more. Finally, dirt or rocks are piled on the edges of the plastic sheets to hold them down. If the bottom of the puddle is flat, well over 90% of the water can be siphoned out.

Once the puddle is built it would be used by adding water each day, either by folding back the top 2 layers of plastic in one corner and adding water by bucket, or by using a fill siphon. The fill siphon should NOT be the same siphon that is used to drain the puddle, as the fill siphon is recontaminated each day, while the drain siphon MUST REMAIN CLEAN. Once in place the drain siphon should be left in place for the life of the puddle.

The only expensive materials used to make the puddle are a pasteurization indicator ($2-$3), a siphon tube (about $1), and 4 sheets of plastic (about $2 for the size tested). Many tests were done in the spring and summer of 1994 in Berkeley, California. On days with good sunshine the required temperature was achieved even with 68 liters (17 gallons) of water corresponding to a depth of 62 mm (2 1/2 inches). With thinner water layers higher temperatures can be reached. With 24 liters (6 gallons) corresponding to a depth of 21 mm (1 inch) 80° C (176° F) was achieved on one day.

The solar puddle works even under conditions that are not ideal. Condensation in the top layer of plastic doesn't seem to be a problem, though if one gets a lot of condensation the top layer should be pulled back to let the condensation evaporate. Small holes in the top layers don't make much difference. The device works in wind, or if the bottom insulation is damp. The water temperature is uniform throughout the puddle to within 1° C (2° F).

After some months the top plastic layers weaken under the combined effects of sun and heat and have to be replaced, but this can be minimized by avoiding hot spots such as places that are exposed to the sun but not cooled by the water. Another option would be to use a grade of plastic that is more resistant to sunlight. The two bottom layers of plastic tend to form tiny tears unless one of very careful in handling them. This is why there are two layers on the bottom. A tiny hole may let a little water through and dampen the solid insulation, but this is not a big problem.

There are many variations of the solar puddle. The least expensive form of a solar puddle is built into the ground as in Fig. 4, but a puddle could be built with wooden sides on top of the ground, on a tabletop, or on a roof. We've been able to put the top layer of plastic into a tent-like arrangement that sheds rain. This would be good in a place that gets frequent brief showers. Adding a second insulating layer of air makes the device work even better, though this adds the cost of an extra layer of plastic. As mentioned the device can cover a larger or smaller area if more or less water is desired. A larger puddle would have a higher initial cost, but a lower unit cost for the water, since the same drain line and water pasteurization indicator could be used. One could make a water heater by roughly tripling the amount of water so that the maximum temperature was only 50° C (120° F) or so, and this water would stay warm well into the evening hours. This water wouldn't be pasteurized though. One could help solve the problem of dirty water vessels by putting drinking cups into the solar puddle and pasteurizing them along with the water. The solar puddle could possibly cook foods like rice on an emergency basis, perhaps in a refugee camp.

Cost Summary

The table below shows an approximate cost summary of the basic methods of water pasteurization described in this document. The initial cost is the amount of money that needs to be spent to get the system running. The water produced per dollar of long term cost is based on a 5-year lifetime, and includes expected maintainance costs and replacement parts. In some cases, a), b), and c) in particular, the maintainance costs are small. For the solar puddle, cases e) and f), the replacement costs for the plastic layers that degrade in the sunlight make up the majority of the long-term cost.

The assumption used in these calculations are:

1. The fuel cost is $0.02 per liter of boiled water (cases a) and b)). This number comes from a recent issue of the Solar Cookers International newsletter, and is the amount of money that some people in the developing world are willing to pay for the fuel to boil drinking water.
2. Pasteurization indicators must be replaced twice in 5 years (cases b), c), e) and f)).
3. Thermostatic valves must be replaced once in 5 years (case d)).
4. For the solar puddle the top 2 layers of plastic are replaced every 3 months, while the bottom 2 layers are replaced every 6 months (cases e) and f)).

System Name	Initial Cost (US dollars)	Liters of Water per Dollar (long term)
a) Flame-heated water pot (heated to boiling with no pasteurization indicator)	small	50
b) Flame-heated water pot with pasteurization indicator	3	96
c) Solar Box Cooker with pasteurization indicator	23	375
d) PAX unit with recuperator	65	580
e) Solar Puddle ("family size")	6	1800
f) Solar Puddle (community size, 10 ft. by 25 ft.)	25	3500

It can be seen that the systems using fuel have low initial cost but high long term cost. The pasteurization indicator is an inexpensive way of nearly doubling the water produced per unit of fuel, though the long term costs of such systems are still high due to the cost of the fuel. The solar puddle has low initial cost and low long term costs, but involves the work of replacing the plastic layers frequently.

Conclusion

In this document water pasteurization has been presented as a way of providing clean drinking water in developing countries. Several techniques for pasteurizing water have been presented here. Some of these methods are less expensive, some produce more water per day, and some are in the form of a compact device that is easy to ship and set up in the field. Pasteurization is only one way of providing clean water. The purpose of this document is not to say that pasteurization is the best way of providing drinking water or to say that one pasteurization technique is necessarily better than other. As always, the selection of a method for providing clean water should be based on local conditions, and the selection process should include a variety of social factors as well as the technical and cost factors explored here. Field experience shows that education is also necessary to achieve successful results with any water system.

References:

1. UNICEF, The State of the World's Children, 1988, Oxford University Press, pg. 3, 1988.

2. UNICEF, The State of the World's Children, 1989, Oxford University Press, pg. 48, 1989.

3. Ciochetti, D. A., and Metcalf, R. H., Pasteurization of Naturally Contaminated Water with Solar Energy, Applied and Environmental Microbiology, 47:223-228, 1984.

4. Recent Advances in Devices for the Heat Pasteurization of Drinking Water in the Developing World, Dale Andreatta, P. E., Derek T. Yegian, Lloyd Connelly, and Robert H. Metcalf, Proceedings of the 29th Intersociety Energy Conversion Engineering Conference, 1994.

See also Solar Water Pasteurizers Make Safe Drinking Water in Tanzania

For questions or comments, contact webmaster@solarcooking.org

Recent Advances in Solar Water Pasteurization

Boiling isn't necessary to kill disease microbes

The main purpose of solar cookers is to change sunlight into heat which is then used to cook foods. We are all familiar with how successful solar cookers are at cooking and baking a wide variety of foods. In this article I want to consider using the heat in solar cookers for purposes other than cooking. My main focus will be solar water pasteurization, which can complement solar cooking and address critical health problems in many developing countries.

The majority of diseases in developing countries today are infectious diseases caused by bacteria, viruses, and other microbes which are shed in human feces and polluted water which people use for drinking or washing. When people drink the live microbes, they can multiply, cause disease, and be shed in feces into water, continuing the cycle of disease transmission.

Worldwide, unsafe water is a major problem. An estimated one billion people do not have access to safe water. It is estimated that diarrheal diseases that result from contaminated water kill about 2 million children and cause about 900 million episodes of illness each year.

Boiling contaminated water

How can infectious microbes in water be killed to make the water safe to drink? In the cities of developed countries this is often guaranteed by chlorination of water after it has been filtered. In developing countries, however, city water systems are less reliable, and water from streams, rivers and some wells may be contaminated with human feces and pose a health threat. For the billion people who do not have safe water to drink, what recommendation do public health officials offer? The only major recommendation is to boil the water, sometimes for up to 10 minutes. It has been known since the time of Louis Pasteur 130 years ago that heat of boiling is very effective at killing all microbes which cause disease in milk and water.

If contaminated water could be made safe for drinking by boiling, why is boiling not uniformly practiced? There seem to be five major reasons: 1) people do not believe in the germ theory of disease, 2) it takes too long, 3) boiled water tastes bad, 4) fuel is often limited or costly, 5) the heat and smoke are unpleasant.

Some examples of the cost of boiling water are worth mentioning. During the cholera outbreak in Peru, the Ministry of Health urged all residents to boil drinking water for 10 minutes. The cost of doing this would amount to 29% of the average poor household income. In Bangladesh, boiling drinking water would take 11% of the income of a family in the lowest quartile. In Jakarta, Indonesia, more than $50 million is spent each year by households for boiling water. It is estimated that in the city of Cebu in the Philippines, population about 900,000, about half the families boil their drinking water, and the proportion is actually higher for families that obtain their water from an unreliable chlorinated piped supply. Because the quantities of fuel consumed for boiling water are so large, approximately 1 kilogram of wood to boil 1 liter of water, and because firewood, coal, and coke are often used for this purpose, an inadequate water supply system significantly contributes to deforestation, urban air pollution, and other energy-related environmental effects.

If wood, charcoal, or dung is used as fuel for boiling water, the smoke creates a health hazard, as it does all the time with cooking. It is estimated that 400 to 700 million people, mainly women, suffer health problems from this indoor air

pollution. As a microbiologist, I have always been perplexed as to why boiling is recommended, when this is heat far in excess of that which is necessary to kill infectious microbes in water. I presume the reason boiling is recommended is to make sure that lethal temperatures have been reached, since unless one has a thermometer it is difficult to tell what temperature heated water has reached until a roaring boil is reached. Everyone is familiar with the process of milk pasteurization. This is a heating process which is sufficient to kill the most heat resistant disease causing microbes in milk, such as the bacteria which cause tuberculosis, undulant fever, streptococcal infections and Salmonellosis. What temperatures are used to pasteurize milk? Most milk is pasteurized at 71.7° C (161° F) for only 15 seconds. Alternatively, 30 minutes at 62.8° C (145° F) can also pasteurize milk. Some bacteria are heat resistant and can survive pasteurization, but these bacteria do not cause disease in people. They can, however, spoil the milk, so pasteurized milk is kept refrigerated.

There are some different disease microbes found in water, but they are not unusually heat resistant. The most common causes of water diseases, and their heat sensitivity, are presented in Table 1. The most common causes of acute diarrhea among children in developing countries are the bacteria Escherichia coli and Shigelia SD. and the Rotavirus group of viruses. These are rapidly killed at temperatures of 60° C or greater.

Solar water pasteurization

As water heats in a solar cooker, temperatures of 56° C and above start killing disease-causing microbes. A graduate student of mine, David Ciochetti, investigated this for his master's thesis in 1983, and concluded that heating water to 66° C in a solar cooker will provide enough heat to pasteurize the water and kill all disease causing microbes. The fact that water can be made safe to drink by heating it to this lower temperature—only 66° C—instead of 100° C (boiling) presents a real opportunity for addressing contaminated water in developing countries.

Testing water for fecal contamination

How can one readily determine if the water from a well, pump, stream, etc. is safe to drink? The common procedure is to test the water for bacterial indicators of fecal pollution. There are two groups of indicators which are used. The first is the coliform bacteria which are used as indicators in developed countries where water is chlorinated. Coliform bacteria may come from feces or from plants. Among the coliform bacteria is the second indicator, Escherichia coli. This bacterium is present in large numbers in human feces (approximately 100,000,000 per gram of feces) and that of other mammals. This is the main indicator used if water is not chlorinated. A water source containing 100 E. coli per 100 milliliters poses a substantial risk of disease.

The standard method of testing water for the presence of coliforms and E. coli requires trained personnel and a good laboratory facility or field unit which are usually not present in developing countries. Thus, water supplies are almost never tested.

A new approach to testing in developing countries

In 1987, the Colilert MPN Test (CLT) was introduced as the first method which used a defined substrate technology to simultaneously detect coliforms and E. coli. The CLT comes as dry chemicals in test tubes containing two indicator nutrients: one for coliforms and one for E. coli. The CLT involves adding 10 ml of water to a tube, shaking to dissolve the chemicals, and incubating at body temperature for 24 hours. I prefer incubating tubes under my belt against my body. At night I sleep on my back and use night clothes to hold the tubes against my body.

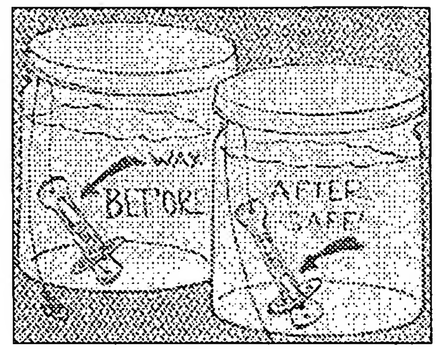
If no coliform bacteria are present, the water will remain clear. However, if one or more coliforms are present in the water, after 24 hours their growth will metabolize ONPG and the water will change in color from clear to yellow (resembling urine). If E. coli is among the coliform bacteria present, it will metabolize MUG and the tube will fluoresce blue when a battery-operated, long-wave ultraviolet light shines on it, indicating a serious health hazard. I have invited participants at solar box cooker workshops in Sierra Leone, Mali, Mauritania, and Nepal to test their home water supplies with CLT. One hundred and twenty participants brought in samples. In all four countries, whether the water was from urban or rural areas, the majority of samples contained coliforms, and at least half of these had E. coli present. Bacteriological testing of the ONPG and MUG positive tubes brought back from Mali and Mauritania verified

the presence of coliforms/E. coli in approximately 95% of the samples. It is likely that soon the Colilert MPN test will be modified so that the test for E. coli will not require an ultraviolet light, and the tube will turn a different color than yellow if E coli is present. This will make the test less expensive and easier to widely use in developing countries to assess water sources.

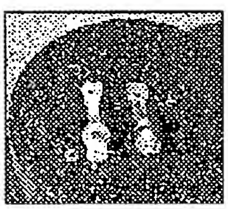
Effect of safe water on diarrhea in children

What would be the effect if contaminated water could be made safe for drinking by pasteurization or boiling? One estimate in the Philippines predicts that if families using moderately contaminated wells (100 E. coli per 100 ml) were able to use a high-quality water source, diarrhea among their children would be reduced by over 30%. Thus, if water which caused a MUG (+) test were solar pasteurized so it would be clear, this would help reduce the chance of diarrhea, especially in children.

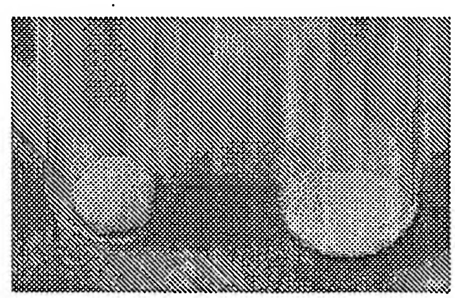
Water pasteurization indicator



How can one determine if heated water has reached 65° C? In 1988, Dr. Fred Barrett (USDA, retired) developed the prototype for the Water Pasteurization Indicator (WAPI). In 1992, Dale Andreatta, a graduate engineering student at the University of California, Berkeley, developed the current WAPI. The WAPI is a polycarbonate tube, sealed at both ends, partially filled with a soybean fat which melts at 69° C ("MYVEROL" 18-06K, Eastman Kodak Co., Kingsport, TN 37662). The WAPI is placed inside a water container with the fat at the top of the tube. A washer will keep the WAPI on the bottom of the container, which heats the slowest in a solar box cooker. If heat from the water melts the fat, the fat will move to the bottom of the WAPI, indicating water has been pasteurized. If the fat is still at the top of the tube, the water has not been pasteurized. The WAPI is reusable. After the fat cools and becomes solid on the bottom, the fish line string is pulled to the other end and the washer slides to the bottom, which places the fat at the top of the tube. Another pasteurization indicator has been developed by Roland Saye which is based on expansion of a bi-metal disc which is housed in a plastic container. This also shows promise and is in the early testing stages.



The WAPI could be useful immediately for people who currently boil water to make it safe to drink. The WAPI will clearly indicate when a safe temperature has been reached, and will save much fuel which currently is being wasted by excessive heating.



[Editor's note: Using Beeswax & Carnauba Wax to Indicate Temperature: In SBJ #15 we discussed using beeswax, which melts at a relatively low 62° C, as an indicator of pasteurization. We have now found that mixing a small amount of carnauba was with the beeswax (~1:5 ratio) raises the melting temperature of the beeswax to 70° - 75° C. Carnauba wax is a product of Brazil and can be bought in the US at woodworking supply stores. Further testing needs to be done to confirm that the melting point remains the same after repeated re-melting. Write to webmaster@solarcooking.org and we will send you a small amount of carnauba wax to experiment with.]

Different strategies for solar water pasteurization

The solar box cooker was first used to pasteurize water. David Ciochetti built a deep dish- solar box cooker to hold several gallons of water. At this time of the year in Sacramento, three gallons could be pasteurized on our typical sunny days.

Dale Andreatta and Derek Yegian of the University of California. Berkeley, have developed creative ways to greatly increase the quantity of water which can be pasteurized, as we will hear about at this conference.

I am also excited about the possibility of pasteurizing water using the simple solar panel cookers. By enclosing a dark water container in a polyester bag to create an insulating air space, and by using lots of reflectors to bounce light onto the jar, it is possible to pasteurize useful amounts of water with a simple system. It takes about four hours for me to pasteurize a gallon of water in the summer with the system I am using. Solar panel cookers open up enormous possibilities for heating water not only for pasteurization, but also for making coffee and tea, which are quite popular in some developing countries. The heated water can also be kept hot for a long time by placing it in its bag inside an insulated box. In the insulated container I use, a gallon of 80° C water will be approximately 55° C after 14 hours. Water at a temperature of 55° C will be about 40° C after 14 hours, ideal for washing/shaving in the morning.

I will close with some advice from the most famous microbiologist, who pioneered the use of vaccinations in the 1890s: Louis Pasteur. When he was asked the secret of his success, he responded that above all else, it was persistence. I will add that you need good data to be persistent about, and we certainly have that with solar cookers; the work in Sacramento, Bolivia, Nepal, Mali, Guatemala, and wherever else the sun shines. Continued overuse of fuelwood is non-sustainable. We need to persist until the knowledge we have spreads and becomes common knowledge worldwide.

For questions or comments contact Dr. Robert Metcalf at rmetcalf@csus.edu.

Dr. Robert Metcalf
1324 43rd St.
Sacramento, California 95819 USA.

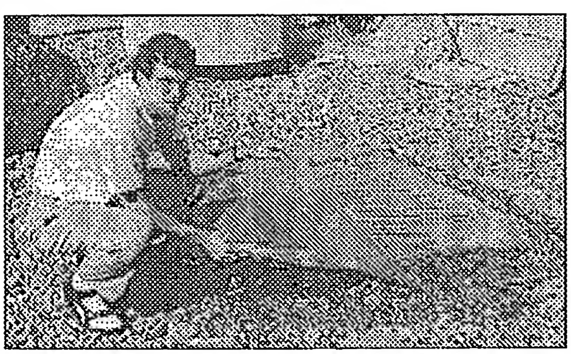
You can hear some of Dr. Metcalf's speeches here.

IDEXX Laboratories, Inc. makes the Colilert kit and is located at this address:

IDEXX Laboratories, Inc.
One IDEXX Drive
Westbrook, ME 04092
USA

Voice: (800) 321-0207 or (207) 856-0496
Fax: (207) 856-0630

Here is their Web page on the Colilert System.
Here is a large list of international contacts for obtaining and using this system.



See also the Solar Puddle Pasteurizer.

Editor's Note: Testing Water in Developing Countries

The Colilert system makes it possible to test water without the need for a laboratory. IDEXX Laboratories, the manufacturer, recommends that you use five test tubes for each sample. Bob Metcalf explains that five tubes would comprise 50 ml, which is the minimum sample size permitted by US law. This is an unrealistically high standard by

which to judge the water in developing countries where you are examining water that is already being drunk, in spite of the fact that it may be making people sick. By using a single test tube (10 ml) there is a very small chance that your sample missed the small number of bacteria that might have been present.

IDEXX Laboratories will also tell you that you need an incubator to achieve valid results. Again, Bob Metcalf tells us that all that is needed is to keep the tubes close to your body for 36 hours, since body temperature is the correct incubation temperature.

What you are actually measuring in the test is the presence of 1) coliform bacteria, and 2) E. coli, a type of coliform bacteria that is largely found in fecal matter. A positive test for coliform bacteria might be due to coliform bacteria that has washed off of plant leaves , and thus be fairly innocuous. A positive test for E. coli, however, would indicate that any bacteriological contamination was from a fecal source, which might also contain Giardia, cholera, or other serious infectious microbes.

For questions or comments, contact webmaster@solarcooking.org http://solarcooking.org/metcalf.htm

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SODIS Technical Note # 17 SODIS Use: SODIS Bags and Temperature Sensors

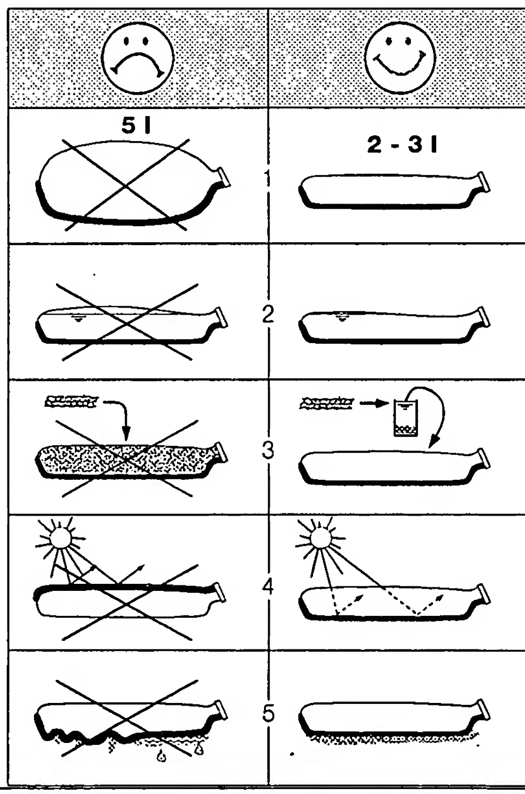
SUMMARY

SANDEC developed different prototype material which has been field tested in the SODIS demonstration projects. SODIS plastic bags were used to attract the interest of the people on the new water treatment method. Temperature sensors have been distributed to record whether the threshold water temperature of 50 °C has been attained or not.

BACKGROUND INFORMATION

Use of SODIS Bags

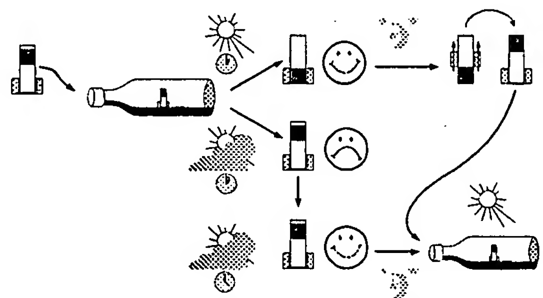
- Fill half of the bags with raw water
- Drive the air out of the bags and close them
- Place the bags in the morning hours on a spot receiving full sunlight throughout the day
- Place the bags in horizontal position on a firm blackened suport, preferably on a corrugated iron sheet/roof or tile roof
- Collect the bags in the late afternoon and store them in a safe place for cooling
- Consume the treated water directly from the bag using a clean glass or cup, store it possibly overnight for additional cooling



Use of Temperature Sensor

The SODIS Temperature Sensor (TS) is an aid for the user. It does not influence the SODIS process but is an indicator for the expected efficiency. When the temperature of 50°C is reached, the paraffine inside the TS melts and drops to the bottom. At this temperature, SODIS needs just one hour to inactivate the pathogens. The following day, the TS can be reused by pulling the screw to the opposite side of the paraffine and placing the TS inside the bag or bottle again (see Figure below).

When 50°C are not reached, the paraffine doesn't melt. If that's the case, the SODIS bag or bottle must be exposed for at least five hours to ensure inactivation. On very cloudy days and/or low temperature, an exposure for two consecutive days should be considered (see also Technical Note #11, Covered Sky Conditions).



Use of the Temperature Sensor. After the paraffine has melted down, the screw is pulled up, making the sensor ready for use again.

REFERENCES

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http://www.sandec.ch